Charmonium spectral functions in two-flavour QCD

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Outline

Background

- J/ψ suppression — a probe of the quark–gluon plasma?
- Quenched lattice results indicate that S-waves survive well into the plasma phase
- Sequential charmonium suppression explains experimental results?
- Uncertainty about which potential to use in potential models
- How reliable are quenched lattice simulations?

Spectral functions

- contain information about the fate of hadrons in the medium, eg charmonium suppression
- can be used to extract transport coefficents
- $\rho_\Gamma(\omega,\vec{p})$ related to euclidean correlator $G_\Gamma(\tau,\vec{p})$ according to

$$G_\Gamma(\tau,\vec{p}) = \int \rho_\Gamma(\omega,\vec{p})K(\tau,\omega)d\omega$$

$$K(\tau,\omega) = \frac{\cosh[\omega(\tau-1/2T)]}{\sinh(\omega/2T)} = e^{\omega\tau}n_B(\omega) + e^{-\omega\tau}[1+n_B(\omega)]$$

- an ill-posed problem — requires a large number of time slices
- use Maximum Entropy Method to determine most likely $\rho(\omega)$

Dynamical anisotropic lattices

- A large number of points in time direction required
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- Introduces 2 additional parameters
- Non-trivial tuning problem

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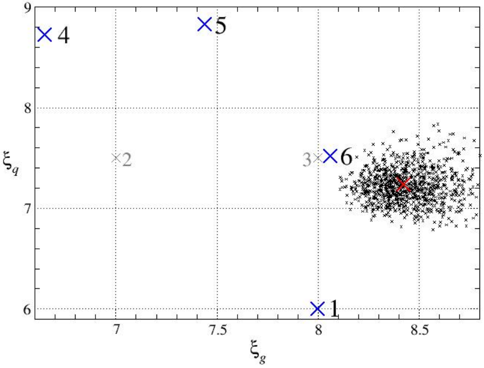
- In dynamical simulations the gauge fields depend on ξ_q^0 so this is no longer possible
- Need a simultaneous two-dimensional tuning procedure:
  - Generate configs at 3 or more points in the (ξ_g^0, ξ_q^0)-plane
  - Determine ξ_g, ξ_q at these points
  - Assume that ξ_g, ξ_q are linear in ξ_g^0, ξ_q^0
    $\longrightarrow$ intersection point where $\xi_g = \xi_q = \xi$

Tuning results



[hep-lat/0604021]

Point 6:
$\xi_g = 5.90(3)$,
$\xi_q = 6.21(10)$

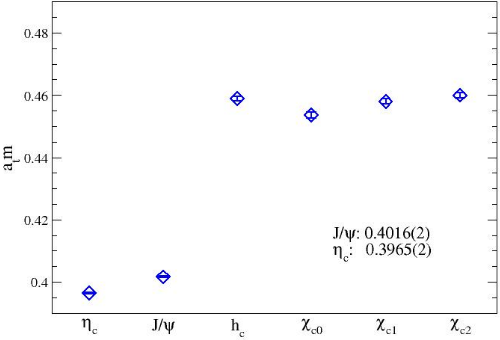
Dynamical anisotropic lattices

Simulation details

Using an improved anisotropic gauge action (TSI3+1) and Wilson+Hamber–Wu fermion action with stout links.

Light quarks	m_π/m_ρ	0.54	
Anisotropy	ξ	6	
Lattice spacing	a_t	0.025fm	
	a_s	0.15 fm	
Lattice volume	N_s^3	8^3	$\rightarrow 12^3$
1/Temperature	N_t	16	$T \sim 2T_c$
		24	$T \sim 1.3T_c$
		32	$T \sim T_c$
		80	$T \sim 0$

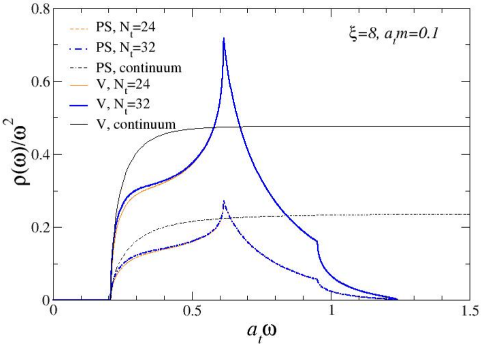
Charmonium spectrum at $T = 0$



1S-1P $\Longrightarrow$
$a_t = 0.0251\text{fm}$,
$a_s = 0.15\text{fm}$.
D-waves, hybrids, radial excitations underway
[Juge et al, 2005]

Charmonium at high temperature

Free spectral functions

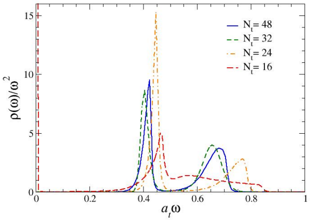


- Cusp at $a_t\omega \sim 0.6$ — observed in lattice data
- Correct artefacts using free lattice $\rho(\omega)$?
- Effects on primary peak at $a_t\omega \sim 0.4$?

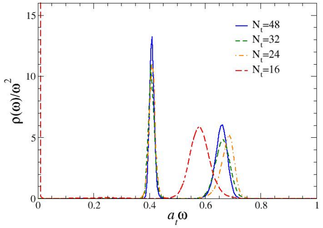
Charmonium spectral functions

Preliminary (2005), not fully tuned [Run 5]

Pseudoscalar

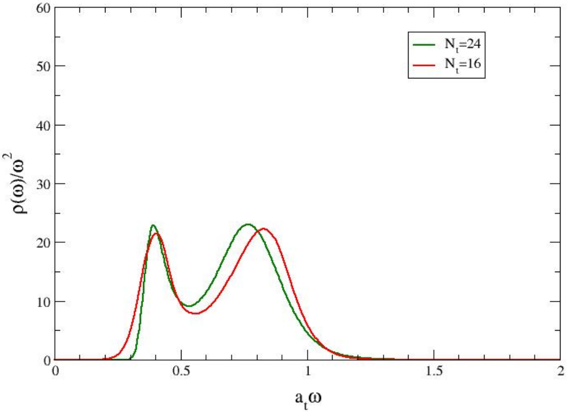


Vector

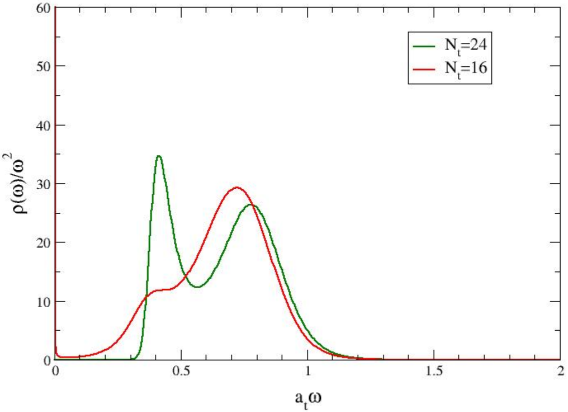


- Melting at $T \lesssim 2T_c$?
- No detailed study of systematics

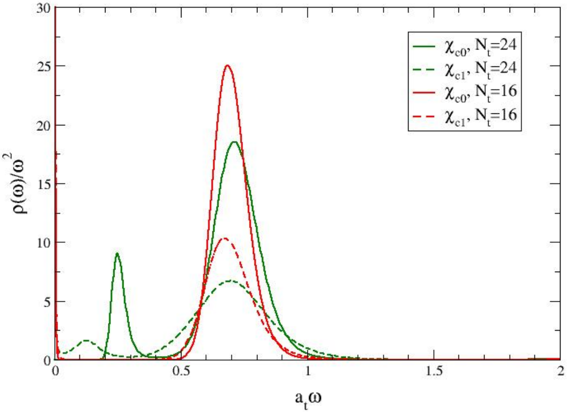
Vector channel



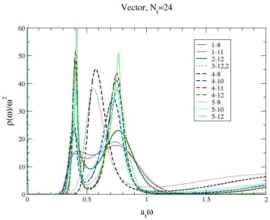
Pseudoscalar channel

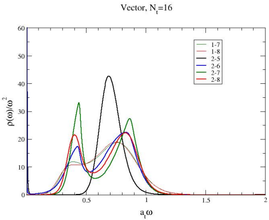


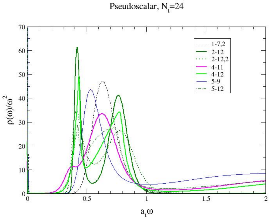
Scalar and axial channel



MEM systematics







- Stable when points near middle of lattice included
- $t = 1, 2 \rightarrow$ peaks washed out
- No dependence on energy resolution
- Little dependence on dropping alternate time slices

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    will perform simulations at fully tuned point
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    $\longrightarrow$ reconstruct correlators?
  - Dependence on default model?
  - Coarse lattice $\longrightarrow$ doubler peak uncomfortably close
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- $N_t = 32$ and 80 data underway

Outlook

- Higher statistics $\longrightarrow$ resolve ψ'?
- Detailed temperature scan?
- $N_s = 12$ simulations underway

- Non-zero momentum
- Light hadrons
- $b\bar{b}$